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STABILITY OF IODINATED SALTS DURING ROASTING AND STORAGE OF PORK MEATBALLS*

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Key words: iodine salts stability, potassium iodide, potassium iodate, thermal treatment, storage, pork

The objective of the study was to determine the effect of table salt iodinated with potassium iodide or iodate added to chopped pork on the stability of iodine during roasting and chilled or frozen storage. During thermal processing (roasting), and chilled or frozen storage of meatballs, better stability was found for iodine introduced along with salt iodinated with potassium iodate. Roasting of meatballs for 15 min resulted in a 5% loss of iodine. Extension of thermal treatment to 30 min resulted in an increase, almost threefold, of iodine loss. Along with the extension of chilled or frozen storage of meatballs a disadvantageous effect of a longer thermal processing was observed on the stability of iodine introduced along with iodinated salt. However, in the case of table salt iodinated with potassium iodide, better iodine retention was observed during storage of samples heated with an applied longer thermal treatment time in comparison to table salt iodinated with potassium iodate.

INTRODUCTION

Amounts of mineral components in ready-to-eat foodstuff, resulting from processing of raw materials of plant and animal origin, are nowadays considered as reliable food quality indicators. One of the important inorganic nutrients is iodine, a deficit of which results in several physiological disorders [Hetzel, 1983, 1989]. The primary method to eliminate the deficit of this microelement is iodination of salt with potassium iodide or iodate. However, due to the complexity of factors affecting iodine content and the magnitude of its losses in the iodinated salt itself, as well as those occurring during processing, mainly thermal treatment, the actual amount of this element supplied to consumers varies considerably and is difficult to determine [Diosady *et al*., 1997; Szymandera-Buszka & Waszkowiak, 2004]. Because these phenomena limit the effectiveness of salt iodination for the purpose of eliminating iodine deficiency disorders, it is necessary to know the exact effect of the above-mentioned factors on the retention of this element.

The objective of the study was to determine the effect of salt iodinated with potassium iodide or iodate added to chopped pork on the stability of iodine during roasting and chilled or frozen storage of minced pork, semi-finished products (pre-fabricated meats) and/or final products such as roasted meatballs.

MATERIALS AND METHODS

Pork (best end of neck) was purchased from an anonymous producer. Meat was minced using a laboratory grinder with 2 mm plate and next all other ingredients were added according to the adopted formulation [Waszkowiak *et al*., 2001]. Meat batter was then mixed thoroughly with experimental ingredients according to the adopted design for individual experiments: salt iodinated with KI – 2% and salt iodinated with KIO_3 – 2%.

In order to maintain identical conditions of determining the kinetics of the thermal treatment, meatballs of identical weight, *i.e.* 50 g±1 g were formed and subjected to thermal processing in a CCC convection oven (Rational, Germany), applying hot air roasting at a temperature of 180°C for 15 and 30 min. After thermal treatment, the meatballs were stored for 9 days in a refrigerator at a temperature of 4°C or for 6 months in a freezer at -18°C. Directly after manufacture (processing) and periodically during storage, quantitative changes in their iodine content were determined using the standard method with the application of potassium thiocyanate [Moxon & Dixon, 1980; Kűhne *et al*., 1993]. The results obtained were subjected to a one-way analysis of variance at a significance level of $\alpha<0.01$.

RESULTS AND DISCUSSION

On the basis of results obtained it was found that extension of thermal treatment by 15 min, and thus the elevation of the experimental product core temperature from 85°C to 93°C, resulted in an increase of iodine losses, irrespective of the type of introduced salt. In the case of 15 min roasting no statistically significant effect of the applied salt type was observed on the stability of iodine (Table 1). Losses of iodine accounted for 5%. Along with the extension of thermal processing to 30 min, and thus extending the time of iodine exposure to elevated temperature [Diosady *et al*., 1997; Diosady & Mannar, 1999], a sta-

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TABLE 1. The influence of the type of iodine salt and roasting time on quantitative changes of iodine.

Treatment			Iodine content	
			mg I/100 g	%
Raw meat		salt + KIO_3	97.06^{*a}	100
		salt + KI	93.71^{b}	100
Roasting time (min)	15	salt + KIO_3	$92.17^{c,b}$	95
		salt + KI	89.36^{d}	95
	30	salt + KIO_3	85.79^{e}	88
		salt + KI	73.79^{f}	79

% – iodine content in comparison with iodine content in raw meat; * means with different letters in the same column are statistically significantly different at $p<0.01$

tistically significant effect was found on the type of iodinated salt on iodine stability. In samples processed with the addition of salt iodinated with potassium iodate increased iodine content by 9 percentage points was observed in relation to potassium iodide. The phenomenon of better stability of iodate may be explained by the fact that it is first degraded to KI, and only later to free iodine [Pokorny *et al*., 1998].

An analysis of iodine stability during chilled and frozen storage showed a better stability of iodine introduced along with salt iodinated with potassium iodate, irrespective of the applied time of thermal treatment. After 6 days of chilled storage, losses of iodine introduced along with potassium iodate ranged from 22 to 30% and were smaller by approx. 22 percentage points in relation to losses of iodine introduced with potassium iodide. After 6 months of frozen storage iodine content decreased by 23 to 28%, which constituted losses smaller by approx. 23 percentage points in relation to salt iodinated with potassium iodide (Tables 2 and 3).

In the case of meatballs with added salt iodinated with potassium iodide better iodine stability was observed for storage of meatballs roasted for 30 min. After 3 days of chilled storage of meatballs processed with the addition of salt iodinated with potassium iodide and roasted for 30 min, the content of iodine was by 9 percentage points better in comparison to the samples roasted for 15 min. These trends were maintained during further storage. In samples previously roasted for 15 min iodine loss amounted to 38%, while in those roasted for 30 min it was 32%. Frozen storage of meatballs with added salt iodinated with potassium iodide resulted in a lower stability of iodine in samples previously roasted for 30 min. After 6 months of storage iodine content was lower by 8 percentage points in relation to the meatballs roasted for 15 min.

This phenomenon may probably be connected with a lower content of water acting as a factor enhancing losses of this element, as well as the formation of skin on the surface during roasting, constituting a barrier also for iodine. Probably it is also connected with the complete passage of KI to iodine and thus the formation of more stable organic bonds [Kühne *et al*., 1993]. Iodine content, as it was shown by the results of this study, is a general form which constitutes a sum of contents of inorganic and organic forms of iodine, thus it would be advisable to conduct further investigations into this phenomenon.

However, it should be stressed that in the final product, irrespective of the applied storage method, iodine content decreases along with the extension of thermal treatment. Tak-

TABLE 2. The influence of the type of iodine salt and roasting time on quantitative changes of iodine during storage at 4°C.

Treatment					Iodine content		
					mg I/100 g	$\%_1$	$\%_2$
Storage time (days)	1	roasting time (min)	15	salt + KIO_3	92.17^{*a}	100	95
				salt + KI	$89.36^{c,b}$	100	95
			30	salt + KIO_3	85.79^{d}	100	88
				salt + KI	73.79^{i}	100	79
	3	roasting time (min)	15	salt + KIO_3	90.68^{b}	98	93
				salt + KI	65.23^{k}	73	70
			30	salt + KIO_3	81.58^{f}	95	84
				salt + KI	60.56^{l}	82	65
	6	roasting time (min)	15	salt + KIO_3	$84.57^{e,d}$	92	87
				salt + KI	$58.80^{\text{ł}}$	66	63
			30	salt + KIO_3	$77.20^{h,g}$	90	80
				salt + KI	55.01^{m}	75	59
	9	roasting time (min)	15	salt + KIO_3	78.10^{g}	85	80
				salt + KI	$55.31^{n,m}$	62	59
			30	salt + KIO_3	70.45^{j}	82	73
				salt + KI	49.87^{o}	68	53

$\%_1$ – iodine content in comparison with iodine content in roasted meatballs; $\%_2$ – iodine content in comparison with iodine content in raw meat; *means with different letters in the same column are statistically significantly different at $p<0.01$

TABLE 3. The influence of the type of iodine salt and roasting time on quantitative changes of iodine during storage at -18°C.

Treatment					Iodine content		
					mg I/100 g	$\%_1$	$\%_2$
Storage time (days)	Just after finishing the thermal treatment		15	salt + KIO_3	92.17^{*a}	100	95
				salt + KI	$89.36^{c,b}$	100	95
			30	salt + KIO_3	85.79^{d}	100	88
				salt + KI	73.79^{i}	100	79
	2	roasting time (min)	15	salt + KIO_3	87.00^{b}	94	90
				salt + KI	75.49^{k}	84	81
			30	salt + KIO_3	80.61^{f}	94	83
				salt + KI	64.34^{l}	87	67
	4	roasting time (min)	15	salt + KIO_3	$81.55^{e,d}$	88	84
				salt + KI	$61.32^{\text{ł}}$	69	65
			30	salt + KIO_3	$73.87^{,g}$	86	76
				salt + KI	57.68^{m}	78	62
	6	roasting time (min)	15	salt + KIO_3	76.60^{g}	83	79
				salt + KI	$53.27^{n,m}$	60	57
			30	salt + KIO_3	72.27^{j}	84	74
				salt + KI	51.90^{o}	70	55

$\%_1$ – iodine content in comparison with iodine content in roasted meatballs; $\%_2$ – iodine content in comparison with iodine content in raw meat; *means with different letters in the same column are statistically significantly different at $p<0.01$

ing into consideration high losses of iodine occurring during the roasting process itself lasting for 30 min, amounting to 47% in the final product with added KI stored for 9 months, they were by 6 percentage points higher in relation to the shorter heating time. Analogously to frozen storage, iodine content in meatballs roasted for 30 min, in comparison to iodine content in meat batter not subjected to thermal processing, was lower by 5 percentage points. Assessing the half-life of added iodine it was found that the application of potassium iodate as an iodine carrier made it possible to double half-life during cold storage (Table 4). Similar trends were observed during frozen storage. Extension of thermal treatment resulted in a shortening of the half-life of iodine during chilled storage by approx. 20%, while during frozen storage it was only by 3%. In turn, in the case of salt iodinated with potassium iodide, higher iodine retention was found during storage of samples heated at a longer thermal processing time in comparison to table salt iodinated potassium iodate.

TABLE 4. The influence of the type of iodine salt and roasting time on half-life period of iodine during storage.

Treatment				Half-life period – t (1/2)(days)
Storage	4°C Roasting time (min)	15	Salt + KIO_3	40
			salt + KI	15
		30	Salt + KIO_3	32
			salt + KI	15
	-18°C Roasting time (min)	15	Salt + KIO_3	671
			salt + KI	236
		30	Salt + KIO_3	691
			salt + KI	348

CONCLUSIONS

1. During thermal treatment (roasting), and chilled and/or frozen storage of meatballs substantially larger stability was found for iodine introduced along with table salt iodinated with potassium iodate.

2. Roasting for 15 min resulted in iodine loss in experimental meatballs amounting to 5%, while extension of thermal treatment to 30 min in an almost threefold increase of iodine losses.

3. Along with the extension of both chilled and frozen storage of meatballs a disadvantageous effect of a longer thermal processing was observed on the stability of iodine introduced with iodinated salt. However, in the case of table salt iodinated with potassium iodide better iodine retention was observed during the storage of samples roasted longer in comparison to salt iodinated with potassium iodate.

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STABILNOŚĆ SOLI JODU PODCZAS PIECZENIA I PÓŹNIEJSZEGO PRZECHOWYWANIA KOTLETÓW Z MIELONEGO MIĘSA WIEPRZOWEGO

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Celem pracy było określenie wpływu rodzaju dodanej soli jodowanej (KI, KIO_3) do mięsa wieprzowego na retencję jodu podczas pieczenia oraz przechowywania chłodniczego i zamrażalniczego potraw mięsnych. W ramach obróbki technologicznej uwzględniono zmienny czas pieczenia 15 i 30 minut. Zmiany ilościowe jodu ogólnego określono metodą makro-chemiczną z tiocyjanianem potasu. Na podstawie uzyskanych wyników badań wykazano, że podczas obróbki cieplnej – pieczenia oraz przechowywania chłodniczego, jak i zamrażalniczego kotletów mielonych, stwierdzono większą stabilność jodu wprowadzonego wraz z solą jodowaną jodanem potasu. Zastosowanie pieczenia przez 15 minut spowodowało ubytki jodu w kotletach mielonych rzędu 5%. Wydłużenie czasu obróbki cieplnej do 30 minut przyczyniło się do około trzykrotnie większych strat jodu. W miarę wydłużania czasu przechowywania chłodniczego, jak i zamrażalniczego kotletów mielonych stwierdzono niekorzystny wpływ dłuższego czasu obróbki cieplnej na retencję jodu wprowadzonego wraz z solą jodowaną. Jednakże w przypadku soli jodowanej jodkiem potasu stwierdzono większą retencję jodu podczas przechowywania prób ogrzewanych z zastosowaniem dłuższego czasu obróbki cieplnej w porównaniu z solą jodowaną jodanem potasu.